MANGALORE UNIVERSITY

Ph.D (Speech and Hearing)

SYNOPSIS

DEVELOPMENT AND VALIDATION OF AUDITORY HABILITATION PROTOCOL FOR CHILDREN WITH COCHLEAR IMPLANTS

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CHAPTER 1

INTRODUCTION

AURAL REHABILITATION/ HABILITATION

Aural rehabilitation (AR) is an essential goal of any Audiologist dealing with children having a hearing impairment (HI). According to Boothroyd (2007), AR is referred to as the lowering of the hearing impairment-induced functionaries, enhancement in activity participation, and improving quality of life by utilizing sensory management, learning, training, and psychoanalysis. It is a necessary aspect to be carried out so that positive improvements will be seen among infants who suffer more from HI issues. It is also responsible for streamlining the service of the offering by providing customizable treatment alternatives to hearing-impaired sufferers (Duldulao& Ramsey, 2013).

AR is defined as any procedure, appliance, communication, facts, or treatment that is used to reduce the un-interactive and psychosocial outcomes of the HI. It is responsible for various services provided and services to individuals suffering from hearing loss (HL) (Makhoba& Joseph, 2016). AR helps in reducing the gaps and maximizes the inflow of information to the brain. It also helps the individual to lay focus and listen to the auditory facts so that the brain will be able to interpret the signals in a better way as cited in Vibrant Hearing, 2015.

Auditory perception training increases awareness and identification of sounds properly. In contrast, the use of visual cues helps in making differences between sounds and words so that children can comprehend the proper meaning of the message. AR also helps in improving speech features so that the child can get overall skill development regarding speech sounds, including speaking rate, quality of voice, and others. It also helps in the development of language by providing learning about various social situations, grammar rules, and others. It also includes the provision of various therapies like HA orientation, auditory training, listening strategies, and speech reading. As a result, the child can get better at learning the language, which helps in his/her personal and academic growth as cited in Hearing Sol, 2019.

CHAPTER 2

REVIEW OF LITERATURE

HEARING LOSS & ITS IMPACT ON COMMUNICATION

HL is mainly related to the absence of hearing abilities due to the presence of confounded functioning of the central auditory system (Oscar et al., 2018). It causes auditory deprivation and the lowering of language development among children. Therefore, it is recommended to introduce communication rehabilitation so that the children who have HL will be able to develop educational and learning skills (Liu, 2016).

Concerning the quality of life(QOL), due to HI, the QOL of the children highly gets distracted. Due to HL, variability & inconsistencies occur in the life of the children, which decreases the QOL to a minimum. The children affected also showed decreased levels of growth and performance in the conduction of school activities and in carrying out social interactions (Roland et al., 2016). Hence, it can be said that HL created many negative implications for children and reduced their growth levels. Individuals with HIs are more likely to experience isolation, which is caused mostly by language development, communication issues, auditory perception, and verbal intelligibility. Parents and teachers regularly remark that deaf children have auditory perception and verbal intelligibility issues (Ashori et al., 2019).

Accordingly, HL adversely affects a youngster's everyday exercises, confidence, and individual independence (Almomani et al., 2021). HL in children can have disastrous effects on a child's growth, speech and language development, and overall development, resulting in a double tragedy of total communication loss. HL can exacerbate other difficulties while placing more burden on children with multiple disabilities, as communication is crucial for life. It can also raise other problems while putting more strain on them owing to developmental demands and post-implantation therapy (Ganesh et al., 2021).

AR of such children mainly includes providing assistive devices and post-amplification training. Cochlear Implants (CI) have changed AR services to be more positive. Pre-lingual deaf children who are born with sensorineural HL due to genetic mutations, perinatal environmental exposures, or idiopathic etiologies account for the bulk of pediatric CI recipients (Swain, 2022).

FACTORS THAT HELP IN SPEEDING THE REHABILITATION AFTER COCHLEAR IMPLANTATION

CI can compensate for HL by providing adequate discourse upgrades to the auditory brain circuits. A CI is a medical device that uses electricity to animate the auditory nerve's winding ganglion cells to restore HL. This device's goal is to convert sound into an electrical signal and send it directly to the hearing nerve, bypassing the damaged hearing mechanical component, most notably the inner ear (Binos et al., 2021).

In children with bilateral significant HL, CI has been recognized as the gold standard of therapy for hearing restoration. When intense auditory verbal therapy is offered in a systematic and tailored manner, CI greatly improves children's audiological and speaking abilities. The habilitationist's roles, as well as parental support, are both critical for achieving the best results. Audiological and speech skills have improved significantly, according to therapists and parents; however, the degree of improvement differs for each child (Venkataramani et al., 2021).

Despite the potential benefits of CI and Government plans to fund CI surgery in India, the attitude of parents (particularly those from rural areas) toward surgery determines the child's fate (Dev et al., 2019). As a result, it was thought that providing CI counseling to parents of children could assist and motivate them to seek early intervention and avoid unnecessary delays in implantation. It is critical to educate parents of children with HL about the quality of life that their children may be missing out on in terms of hearing, speech, and social development if CI is not completed on time (Arumugam et al., 2021).

The rehabilitation process after the CI helps in improving speech perception and cognitive abilities in a positive way. Thus, the individual can improve his/her quality of life and improve social interactions or activities (Mosnier et al., 2015). While making a focus on the factors that help to speed the rehabilitation after CI, the time or age of implantation profoundly impacts the growth process. To assure the best possible development of the child, implantation must be done as soon as the identification of impairment is known. It will not deprive the child of auditory stimulation from the natural surroundings.

Auditory-verbal (AV) therapy facilitates the optimal acquisition of spoken language through listening by newborns, infants, toddlers, and young children who are deaf or hard of

hearing. AV Intervention helps in early diagnosis, one-to-one focused management, and state-of-the-art audiologic management and technology (AG Bell Academy LSLS Certification Handbook, 2017).

As far as the pediatric population is concerned, it can be referred to as Auditory Habilitation rather than Rehabilitation. Rehabilitation enables the individual to relearn a skill that is affected/ lost due to various factors, whereas Habilitation helps in acquiring a new skill. Hence child language development can be addressed as Auditory Habilitation in most cases. The areas of training to be given to the child depends on various factors like present age of the child, age at which the problem started (whether congenital or acquired), age of identification of the problem, site of lesion in HL, degree/ severity of the hearing problem, age at which the child got introduced to various habilitation strategies, etc.

Early intervention and full-time use of hearing equipment, as well as family-centered auditory-verbal intervention, have been found to help children in bridging the language gap and develop age-appropriate language before starting school for this new generation of children with HI. Up to 90% of daily language acquisition is due to overhearing (Wischmann et al., 2022). AVT might be considered a safe option for parents who want to assist their HL children in learning to communicate. Because individuals control the listening experiences provided by AVT, the goal of AVT is for HL children to learn to use hearing as their primary sensory modality in developing speech production abilities (Binos et al., 2021).AT has been proven to be useful in the rehabilitation of children with central auditory processing problems, children with language-learning difficulties, and HA users (Rauch et al., 2021).

NEED FOR THE STUDY

Standardized & structured resource manuals are not available for pre-lingually deaf Indian children who undergo CI. Jones et al., (2014) have reported the urgent need for well-controlled studies examining AVT. Clinicians should stay aware of the consistently advancing writing for this populace. Currently, the pediatric literature is so restricted that a systematic review cannot be used to generate guidelines (Bagatto et al., 2019). The guidelines described here were created using existing literature and physician experience. They should be examined with a critical eye as a study in this rapidly expanding field becomes more widespread (Park et al., 2022).

India being rich in linguistic diversity has 22 official languages and more than 1500 dialects spoken in the country. Hence, it's challenging for professionals to provide services to everyone, due to a variety of variables such as geographic distribution and extensive linguistic and cultural diversity (Mandke&Deshpande, 2015). Kameswaran& Kumar (2018) studied the efficiency of the AVT program in South India, wherein the need for the development of validated indigenous outcome measures has been identified. This can improve the performance of implantees concerning phonetic, linguistic, and socio-cultural ethnicity.

Restoration of hearing ability is the initial step for stimulation of speech and language. Habilitation is the platform for speech and language development. A newly habilitated individual of any age resembles a newborn in the field of hearing, speech, and language. Children implanted with CI needs to be provided systematic auditory verbal training. The therapists and educators attempt to adapt levels of training & methods of training based on experience and peer teaching facilities. It is generally recognized that in the Indian context no systematic manual of AV training has been made available so far.

The present study recognizes the need for a systematic training manual to help children with CI achieve their AV potential attempts to fulfill this gap. Overall, the present study has attempted to select well researched, standardized software that is open sourced and adapted. Few initial levels of tasks are used for training and its results are reported. It is hoped that this attempt using AR will make AVT a totally positive experience.

CHAPTER 3

METHODS

A pilot survey was conducted to identify the services presently available to Cochlear implantees in India; challenges faced and core necessities named “Survey on services available for children who underwent Cochlear Implantation”.

For the study, a questionnaire-based analysis was used. The poll required the primary caretakers of the implanted children, either father or mother, to participate. It was made a point to avoid their concerned AVT specialists and professionals during the survey in order to eliminate any bias. Each question in the material was explained to the interviewee, who was then instructed to encircle the proper responses. For each question, the responses of 25 children were combined and a percentage score was generated. The25 youngsters were all born with hearing loss in both ears and had hearing aids placed in one ear at different periods. The children chosen for the study were those who met the Ministry of Health and Social Welfare's criteria for cochlear implantation. This survey was carried out in 20 aspects given for obtaining responses for the services available for people children who underwent CI.

1. Information regarding available resources for treatment.

A newly implanted pre-lingual hearing-impaired individual resembles a new born in their auditory abilities. They have to undergo systematic, structured and intensive auditory training immediately. 8% of the primary caretaker feels that the information regarding treatment is easily available, 4%feels that the information is sufficient, 68% feels that the information regarding treatment is difficult to gather whereas20% feels the resources for treatment are insufficient.

2. Information available on how to communicate with the deaf child.

It is always challenging to communicate to a newly implanted pre-lingually deaf individual. The communicators have to use some special strategies since they lack auditory input so far and needs some supporting strategies. 64% of the caretakers identify the information available to be insufficient.

3. Guidance available on how to encourage child's communication strategies.

The language acquisition and performance of the implantee depends on the effectiveness of intervention strategies to foster communication. 24% of the primary caretakers feels that the guidance available is sufficient whereas 76% feels that guidance on how to encourage child's communication strategies are not adequate.

4. Information regarding role of parent and caretaker in a deaf child's world.

The primary caretaker or the parent who influences the implantee the most has a critical role to play in child's interventional aspects and training. H.I child needs special attention from caretaker for which they have to be educated and trained. 28% feels that the information regarding role of primary caretaker in a deaf child's world is clear whereas 72% feels that they lack managing skills.

5. Information related to role of family members in the treatment of a hard of hearing child.

The family members too have a vital role to play in an implantees learning life providing nurturing environment and reinforcement. 4% could identify the resources satisfactorily whereas 96% couldn't identify the resources at par.

6. Information related to availability of structured AVT in English language.

The auditory training provided in deaf child's world lacks a standard protocol. Instead, it's an evidence-based practice believing on natural stimulatory environments. The availability of structured AVT in English language is identified to be 16% whereas 84% reports the non-availability of a habilitation guide.

7. Availability of structured AVT in mother tongue.

The AV intervention efficacy will be more if it could be provided in mother tongue. 84% of the children have access to AVT in mother tongue.

8. Information available regarding natural sequential patterns of stimulation.

The AV intervention will be more effective provided natural and realistic ways of stimulation could be availed. 44%reports that the pertaining information's are difficult to gather whereas 56% reports that the information is insufficient.

9. Information regarding guidance from abroad.

The AV intervention is believed to be more structured and effective in abroad countries. The amount of guidance available from such sources like Availability of western treatment materials, online resources, Training packages, Software's, Applications etc depicts that the information is accessible only for 12% of the implantees.

10. Information regarding qualified, skilled and dedicated clinicians.

The availability of qualified, skilled and dedicated clinicians is the key element in AV intervention. The survey has identified the availability of such good professionals to be 32% whereas68% reports reduced efficacy of AV professionals.

11. Contribution of AVT specialist in designing the support needed for cochlear implantee with respect to family.

The family members of the AV client too provide a key role in the communicative development. This needs to be clearly identified and formulated wherever necessary based on the family background and necessities. 76% of the implantees are not getting the concerned advice and support plans from the AV specialist.

12. Consideration of family's culture and lifestyle when working out support plans.

The home training activities and its parameters needs to be designed by the AV specialist studying their family's cultural aspects and lifestyle. 28% only has reported it to be satisfactory.

13. Information regarding the support from all professionals together in co-ordination.

AV intervention can more or less be considered as a multidisciplinary approach consisting of Audiologist, Speech Language Trainer, AV specialist, Psychologist etc. The availability of support from all the professionals together is reported to be around 24%.

14. Information regarding regular monitoring of the implantees hearing levels and necessity by the specialist.

The hearing levels of the implantees need to be monitored through regular mapping or related procedures based on the type of implant done which is responsible for the sequential communicative development of the implantee.56% has reported it to be satisfactory whereas 44% reports it to be insufficient.

15. Information regarding follow up of things as per treatment plan.

An age matched AV treatment plan will help in the better monitoring of achieved milestones and lacking areas which can track prognosis easily. It is also essential to formulate future plans. 80% of the implantees report it to be inadequate.

16. Involvement of AVT specialist with implantee, primary caretaker and family members.

The AV specialist themselves becomes a lead caretaker of the implantee wherein they have to frequently interact with family members and build a good rapport. 44% of the implantees reports limited or absence of interaction with immediate family members.

17. Knowledge and ability of AVT specialist in troubleshooting the implant under emergency conditions.

Cochlear implant processor, battery and its accessories has to be inspected before the commencement of each AV session. Basic trouble shooting needs to be done by the AV specialist since it's impractical to depend on technical person always.56% of the implantees get benefited from the AV specialist itself whereas 44% required escalating it to the next levels for rectification.

18. Average time of AVT intervention undergoing per month.

The language development and communicative ability depends on the time exposed to AV intervention. 8% are getting AV intervention more than 30 hours a month, 48% are undergoing 21-30 hours a month, 12% gets 15-20 hours a month whereas 32% are receiving AV intervention only less than 10 hours a month.

19. How frequently mapping is performed and updated?

Mapping or configuring the implant device to the optimal hearing levels should be done whenever needed to assure proper amplification. 20% of the implantees is getting the service whenever required, 12% is getting on a monthly basis, 32% on a quarterly basis and 36% in half yearly basis.

20. Average time of Audiology services availed per quarter for checking the performance and maintenance of cochlear implant.

The audiologist is the concerned technical person for immediate escalation after AV specialist. The audiology services availed per quarter is found to be 1-2 hours for 28% of the implantees whereas less than an hour for 72% of the implantees.

The outcomes of the survey points to limitations in majority of the realms where AV intervention should be more focused. This could be due to the lack of awareness, limited resource centers, limited professional expertise, limited technical support and moreover unaware of the global consequence and call of action in this respect. Early intervention and fulltime use of hearing equipment, as well as family-centered auditory-verbal intervention (Swain, 2022), have been found to help children bridge the language gap (Lawrence et al., 2020) and develop age-appropriate language before starting school for this new generation of children with HI (Arumugam et al., 2021). The major finding was the lack of training manual available for initiating AR for CI recipients.

AIM OF THE PRESENT STUDY

The present study aims to develop a manual of AVT for auditory rehabilitation of children with implant age of 0-2 years. The objectives of the study are as follows

1. To identify the need of a standardized training material for AV intervention

2. Development of AT activities for the tasks selected.

3. Comparing pre& post performance of participants to validate tasks that would lead to development of a manual.

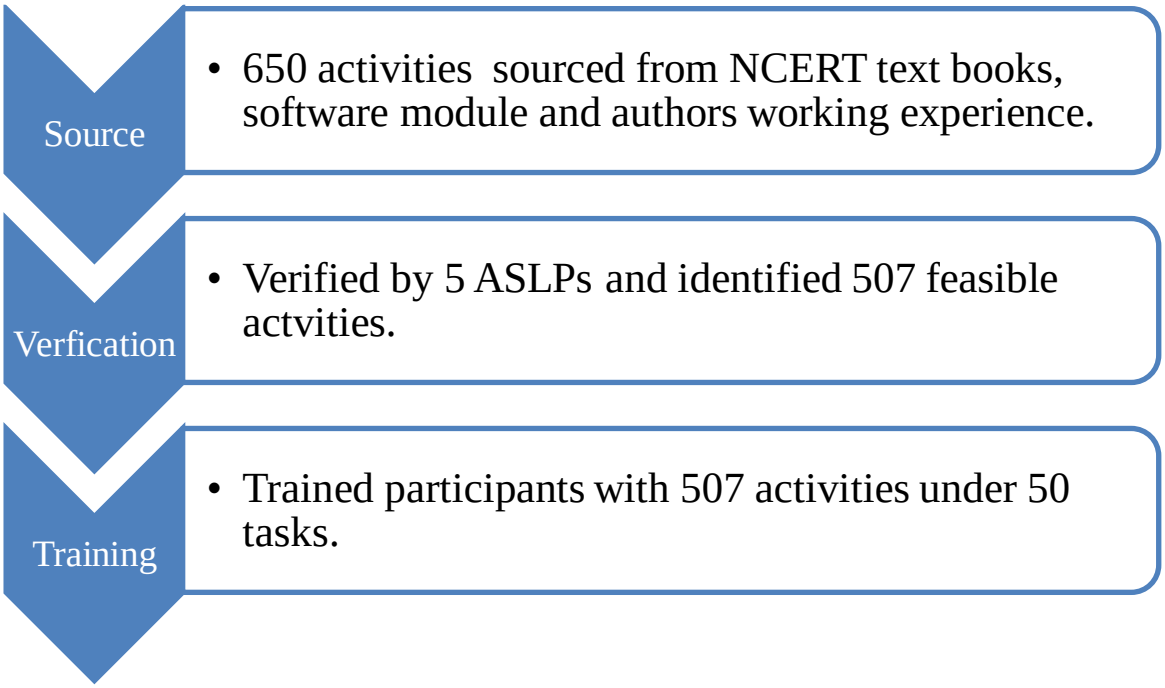
RESEARCH DESIGN

This study was conducted on 60 CI children of age 1-5 years undergoing auditory habilitation program in Coimbatore, Tamilnadu state (Vikram ENT Hospital& Research Institute). Their medium of instruction is English. The children were divided into four age groups based on their stage of treatment, 0-6 months after switch on, 6-12 months after switch on, 12-18 months after switch on and 18-24 months after switch on. Each group consisted of 15 children(N=15) wherein 60 children were trained respective of their

implantage groups. These children underwent CI in any of the one ear. They didn't have any other social and behavioral disturbances.

METHOD USED FOR TRAINING

The tasks for training each group were sourced from Angel Sound software and authors' experience in working with CI children. The items/activities of the training material were selected from NCERT textbooks for the typically developing normal hearing children. A total of 650 activities were selected for the entire study. This was verified by 5 ASLP's and changes were incorporated accordingly. As a rule, an average of 4/5 activities were selected. 80% of the tasks were used for training and 20% for testing. When the subjects fulfilled the testing activities successfully the activities were graded based on complexity. The training activities were then ascertained to the 4 implant-age groups.


Source
• 650 activities sourced from NCERT text books, software module and authors working experience.
Verfication
• Verified by 5 ASLPs and identified 507 feasible actvities.
Training
• Trained participants with 507 activities under 50 tasks.

The children underwent training for 6 months. It consisted of 50 tasks in total wherein 0-6 month's implant age group had 10 tasks, 6-12 months implant age group had 12 tasks, 12-18 months implant age group underwent 12 tasks, and 18-24 months implant age group underwent training of 16 tasks. Each task had different activities based on the complexity of the items.

PARTICIPANTS OF THE STUDY – INCLUSIVE AND EXCLUSIVE CRITERIA

The participants of the study were pre-lingually deaf children who underwent Cochlear Implantation surgery in any of one ear between 1-5 years of age. They were diagnosed to be born congenitally deaf and underwent CI in the Tamilnadu state. The recipients were implanted with MEDEL or COCHLEAR implants. They were not using any other amplification devices in the opposite ear. All the children were intellectually normal without any associated developmental impairments. They were regularly attending habilitation courses after the surgery.

Table 3.1

Classification of participants based on their implant age (0-6 months.)

Sl. No	Name of Child	GENDER	AGE(In Years)
1	A P	M	3.2
2	A J	M	2.6
3	R C S	M	2.4
4	AA	M	2.11
5	AL	M	3.6
6	M R	M	3.1
7	E C	M	2.7
8	A V	F	1.7
9	HZ	F	2.6
10	HD	F	3.6
11	LS	F	3.5
12	KI	M	2.5
13	SH	F	2.8
14	JP	M	2.4
15	R S	M	3.5

Table 3.2

Classification of participants based on their implant age (6-12 months)

Sl. No	Name of Child	GENDER	AGE(In Years)
1	F R	F	3.5
2	L R	F	3.4
3	YS	F	2.8
4	DD	M	2.10
5	SA	F	3.6
6	TH	M	3.5
7	LA	F	3.6
8	HA	M	3.6
9	SU	M	3.4
10	M R	F	3.7
11	RE	M	2.6
12	VI	F	2.6
13	PR	M	2.8
14	H P	M	2.10
15	P S	F	3.6

Table 3.3

Classification of participants based on their implant age (12-18 months)

Sl. No	Name of Child	GENDER	AGE(In Years)
1	A B	M	4.4
2	S C S	F	3.8
3	KE	M	3.8
4	D S	F	3.7
5	M S	M	3.8
6	TA	F	3.6
7	DH	M	3.9
8	PN	M	4.8
9	MG	F	4.7
10	TA	F	4.9
11	TN	M	4.7
12	V S	F	4.6
13	AK	M	3.11
14	SR	M	3.9
15	FA	F	4.7

Table 3.4

Classification of participants based on their implant age (18-24 months)

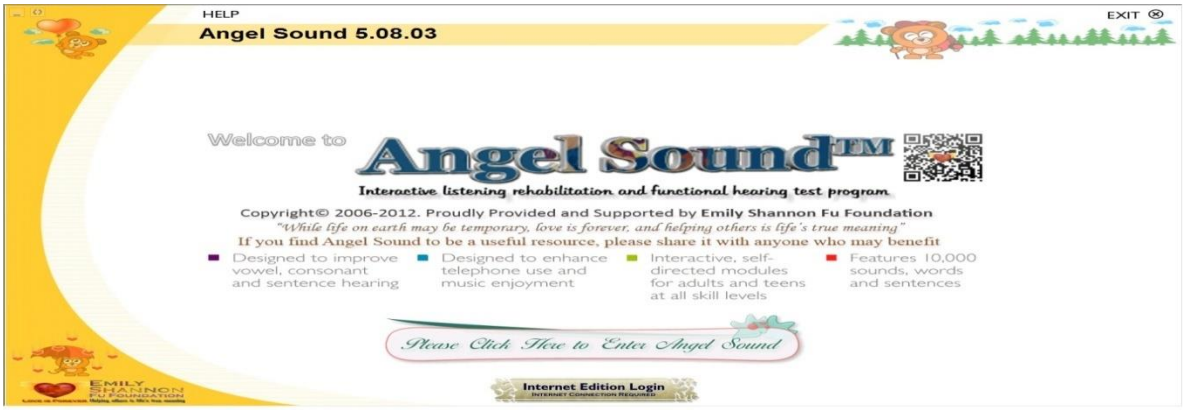
Sl. No	Name of Child	GENDER	AGE(In Years)
1	AY	M	4.6
2	RD	M	4.7
3	JH	F	5.7
4	MR	M	4.11
5	AR	F	3.9
6	LY	M	4.6
7	AN	M	4.8
8	JL	M	5.10
9	MM	M	4.9
10	IM	M	4.11
11	YE	M	4.10
12	SH	M	3.6
13	SR	F	4.8
14	AA	F	4.6
15	AM	M	5.9

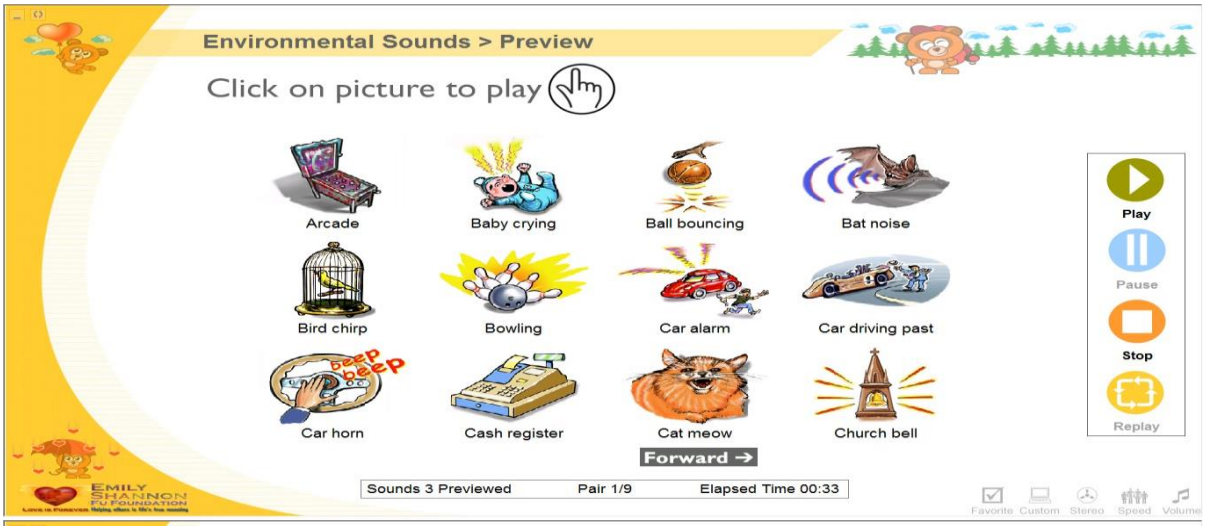
TRAINING ENVIRONMENT

The participants were trained for six months based on their commencement of habilitation course after switch-on. The training was given as a part of their regular rehabilitation training and carried out in individual therapy cabins where outside noises were minimal. Initially, the children were provided visual, tactile, and auditory cues wherein the visual and tactile cues were subsequently eliminated according to the children's progress. The primary parent was present along with the speech therapist for the majority of the training session. Each session lasts for about 40 minutes followed by 5 minutes of parental counseling. All the children attended 2-3 sessions a week lasting for 6 months. The performance of children on various tasks and activities was recorded in every session and moved to higher tasks once the child achieves the particular target task.

DATA COLLECTION AND ANALYSIS

The regular listening check was done using monitor headphones& signal test device. Perception of ling sounds also were checked to ensure implant integrity and speech processor functionality. Behavioural responses were obtained once in a month using freefield audiometry in order to ensure that the hearing levels were well accommodated within the speech banana. Mappings were conducted once in four weeks until auditory perceptions of all sounds (vowels& consonants) were achieved clearly. A dynamic range of 30-40 CL was always maintained. The clinician recorded the responses of each session in a spreadsheet. The average number of trials and time (in months) each participant took for achieving the particular activity under the task was recorded separately. Instrumental tasks and activities were presented through "Angel Sound" software version 5.5using a laptop and delivered with the help of Bose surround speakers. Other tasks and activities were presented through picture cards and noise makers.


HELP
EXIT
Angel Sound 5.08.03
Welcome to
Angel Sound™
Interactive listening rehabilitation and functional hearing test program
Copyright© 2006-2012. Proudly Provided and Supported by Emily Shannon Fu Foundation
"While life on earth may be temporary, love is forever, and helping others is life's true meaning"
If you find Angel Sound to be a useful resource, please share it with anyone who may benefit
Designed to improve vowel, consonant and sentence hearing
Designed to enhance telephone use and music enjoyment
Interactive, self-directed modules for adults and teens at all skill levels
Features 10,000 sounds, words and sentences
Please Click Here to Enter Angel Sound
Internet Edition Login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Click on picture to play
Arcade
Baby crying
Ball bouncing
Bat noise
Bird chirp
Bowling
Car alarm
Car driving past
Car horn
Cash register
Cat meow
Church bell
Forward →
Play
Pause
Stop
Replay
Sounds 3 Previewed
Pair 1/9
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Favorite
Custom
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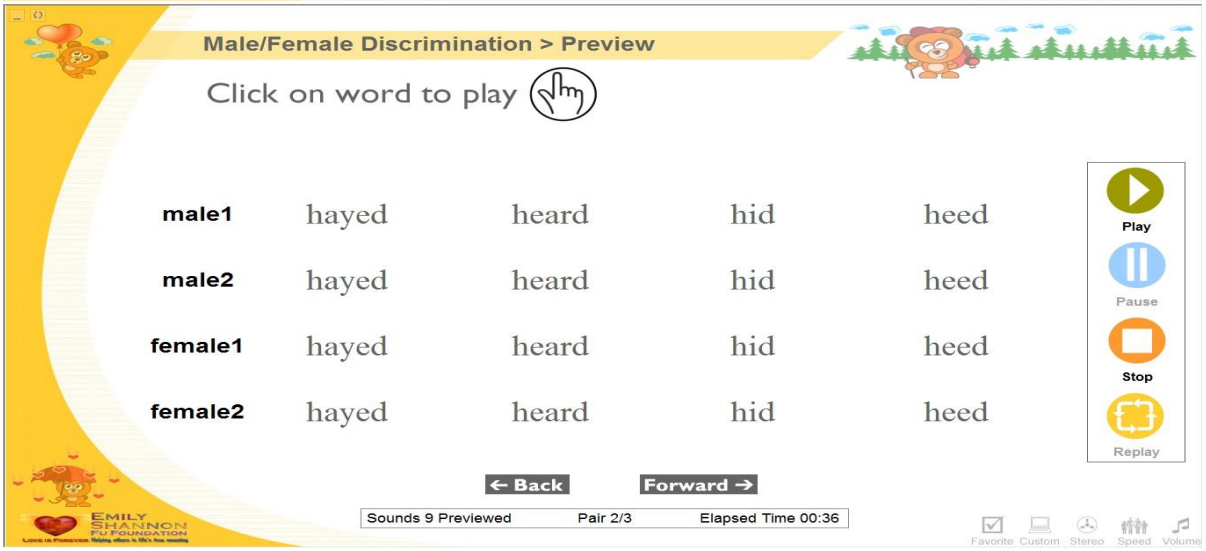
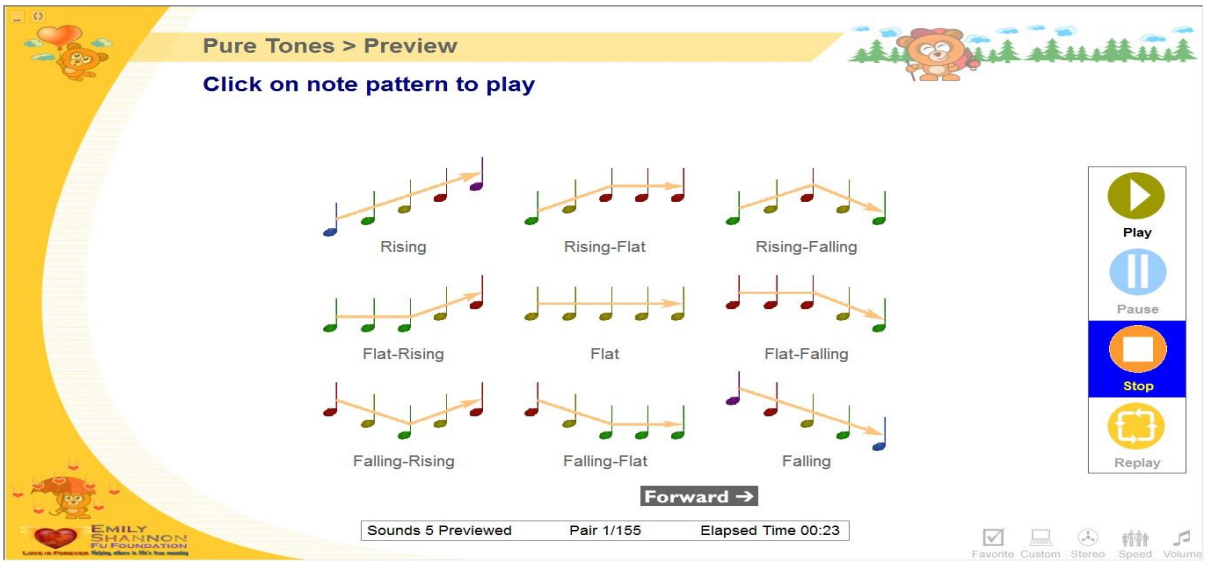

Male/Female Discrimination > Preview
Click on word to play
male1 hayed heard hid heed
male2 hayed heard hid heed
female1 hayed heard hid heed
female2 hayed heard hid heed
← Back
Forward →
Play
Pause
Stop
Replay
Sounds 9 Previewed
Pair 2/3
Elapsed Time 00:36
Favorite
Custom
Stereo
Speed
Volume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Click on note pattern to play
Rising
Rising-Flat
Rising-Falling
Flat-Rising
Flat
Flat-Falling
Falling-Rising
Falling-Flat
Falling
Forward →
Play
Pause
Stop
Replay
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Pair 1/155
Elapsed Time 00:23
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Custom
Stereo
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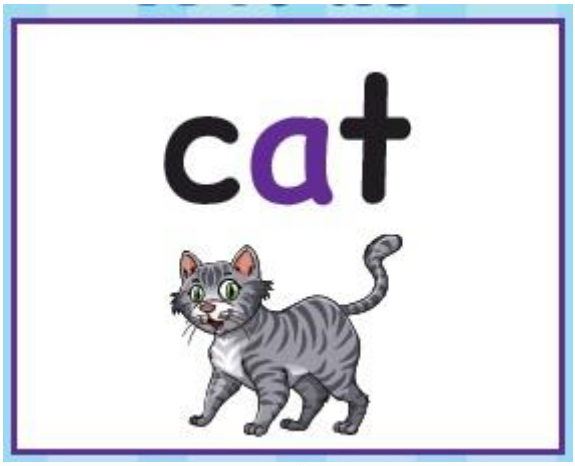
Volume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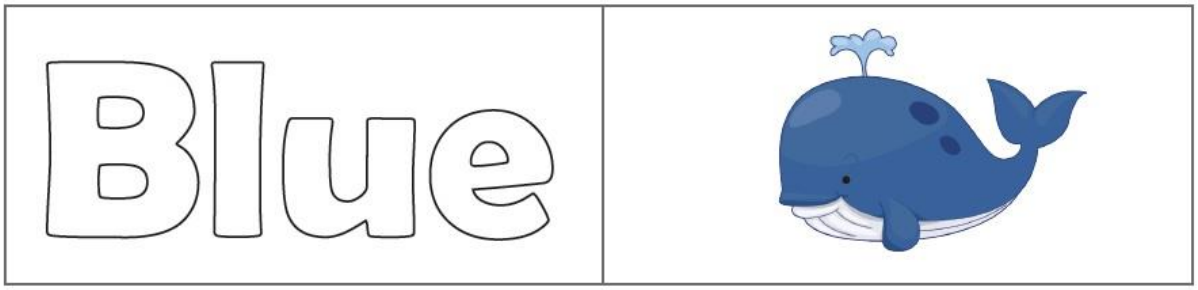
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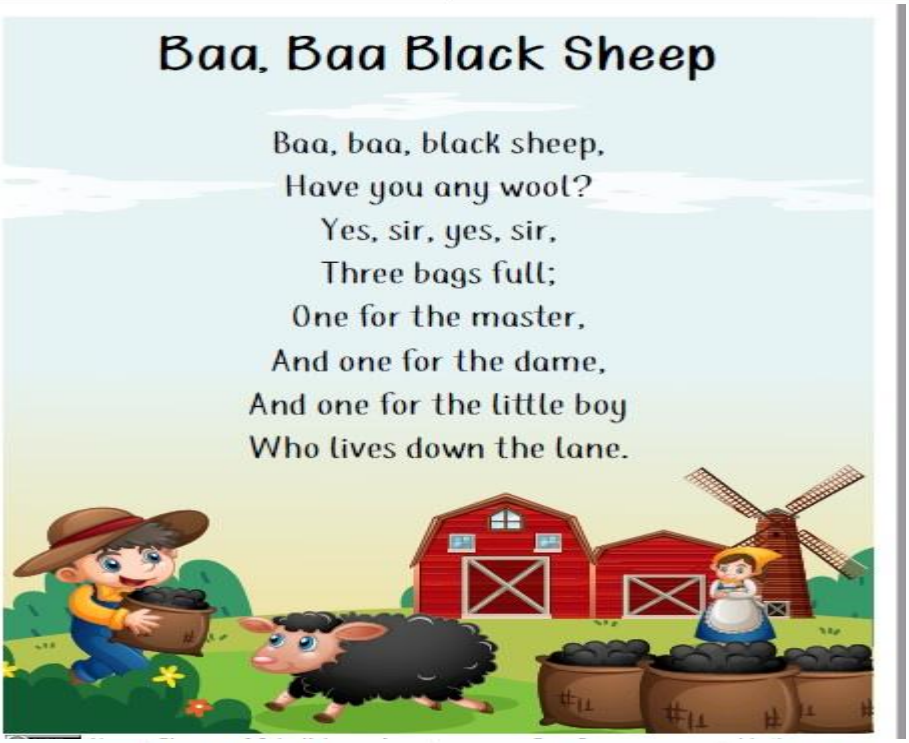

Baa, Baa Black Sheep
Baa, baa, black sheep,
Have you any wool?
Yes, sir, yes, sir,
Three bags full;
One for the master,
And one for the dame,
And one for the little boy
Who lives down the lane.

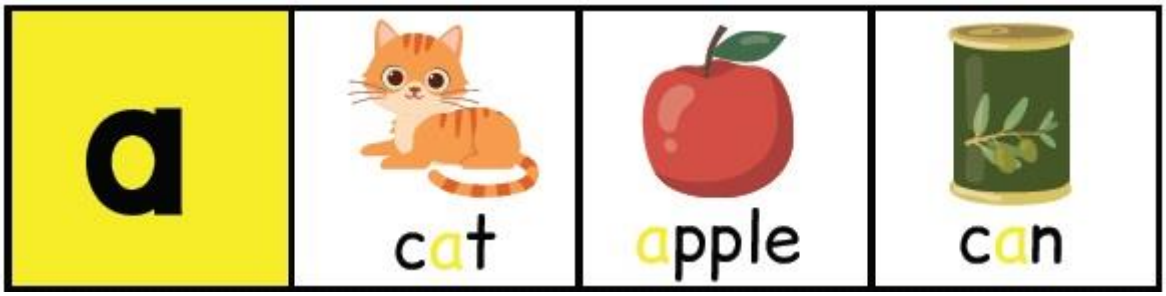

a
cat
apple
can

Table 3.5

Training tasks and activities for children undergoing habilitation from 0-6 month's period.

Task Sl. No	Task Name	No of Activities/Items
1	ENVIRONMENTAL SOUNDS	5
2	CONDITIONED PLAY RESPONSE	6
3	LINGS SIX SOUND DETECTION	6
4	INCREASED VOWEL VOCALIZATION	4
5	NAME CALL RESPONSE	1
6	SAME OR DIFFERENT TASKS	7
7	SPONTANEOUS ALERTING RESPONSES	10
8	SUPRASEGMENTALS	9
9	CONSONANT-VOWEL VOCALIZATION	6
10	PRODUCTION OF SIMPLE WORDS	20

Table 3.6

Training tasks and activities for children undergoing habilitation from 6-12 months period.

Task Sl. No	Task Name	No of Activities/Items
1	CONSONANT-VOWEL VOCALIZATION	5
2	PRODUCTION OF SIMPLE WORDS – ANIMALS	10
3	PRODUCTION OF SIMPLE WORDS –BODY PARTS	5
4	PRODUCTION OF SIMPLE WORDS-COLORS	5
5	PRODUCTION OF SIMPLE WORDS –FOOD	10
6	PRODUCTION OF SIMPLE WORDS –FAMILY	5
7	PRODUCTION OF SIMPLE WORDS –NUMBERS	10
8	PRODUCTION OF SIMPLE WORDS –ACTIONS	10
9	PRODUCTION OF SIMPLE WORDS – GENERAL	45
10	TWO WORD COMMANDS	10
11	FAMILIAR EXPRESSIONS	7
12	Pure-tone Discrimination	3

Table 3.7

Training tasks and activities for children undergoing habilitation from 12-18 months period.

Task Sl. No	Task Name	No of Activities/Items
1	SINGLE DIRECTIONS	20
2	TWO DIRECTIONS	10
3	CLASSROOM INSTRUCTIONS	10
4	PRODUCTION OF SIMPLE WORDS – ANIMALS	10
5	PRODUCTION OF SIMPLE WORDS -BODY PARTS	5
6	PRODUCTION OF SIMPLE WORDS-COLORS	5
7	PRODUCTION OF SIMPLE WORDS –FOOD	10
8	PRODUCTION OF SIMPLE WORDS –FAMILY	5
9	PRODUCTION OF TWO DIGIT NUMBERS	10
10	PRODUCTION OF SIMPLE WORDS –ACTIONS	10
11	PRODUCTION OF SIMPLE WORDS – GENERAL	45
12	Melodic Variations – Puretone	5

Table 3.8

Training tasks and activities for children undergoing habilitation from 18-24 months period.

Task Sl. No	Task Name	No of Activities/Items
1	THREE STEP DIRECTIONS	8
2	MULTIELEMENT DIRECTIONS	10
3	IMITATION/ PRODUCTION OF A WORD-ONOMATOPOEIA	20
4	PRODUCTION OF SIMPLE WORDS – ANIMALS	10
5	PRODUCTION OF SIMPLE WORDS -BODY PARTS	5
6	PRODUCTION OF SIMPLE WORDS-COLORS	5
7	PRODUCTION OF SIMPLE WORDS –FOOD	10
8	PRODUCTION OF SIMPLE WORDS –FAMILY	5
9	PRODUCTION OF TWO/THREE DIGIT NUMBERS	10
10	PRODUCTION OF SIMPLE WORDS –ACTIONS	10
11	PRODUCTION OF SIMPLE WORDS – GENERAL	45
12	FAMILIAR EXPRESSIONS	5
13	Melodic Variations	5
14	RHYME RECITATION-PARTLY	5
15	STORY NARRATION-PARTLY	5
16	Male/ Female Voice Identification	4

Scoring

The implant age at which each participant learned the particular activity is recorded. The training activities which atleast 70% of the participants could learn were identified and recorded for developing the AV treatment manual.

Consolidation of Results

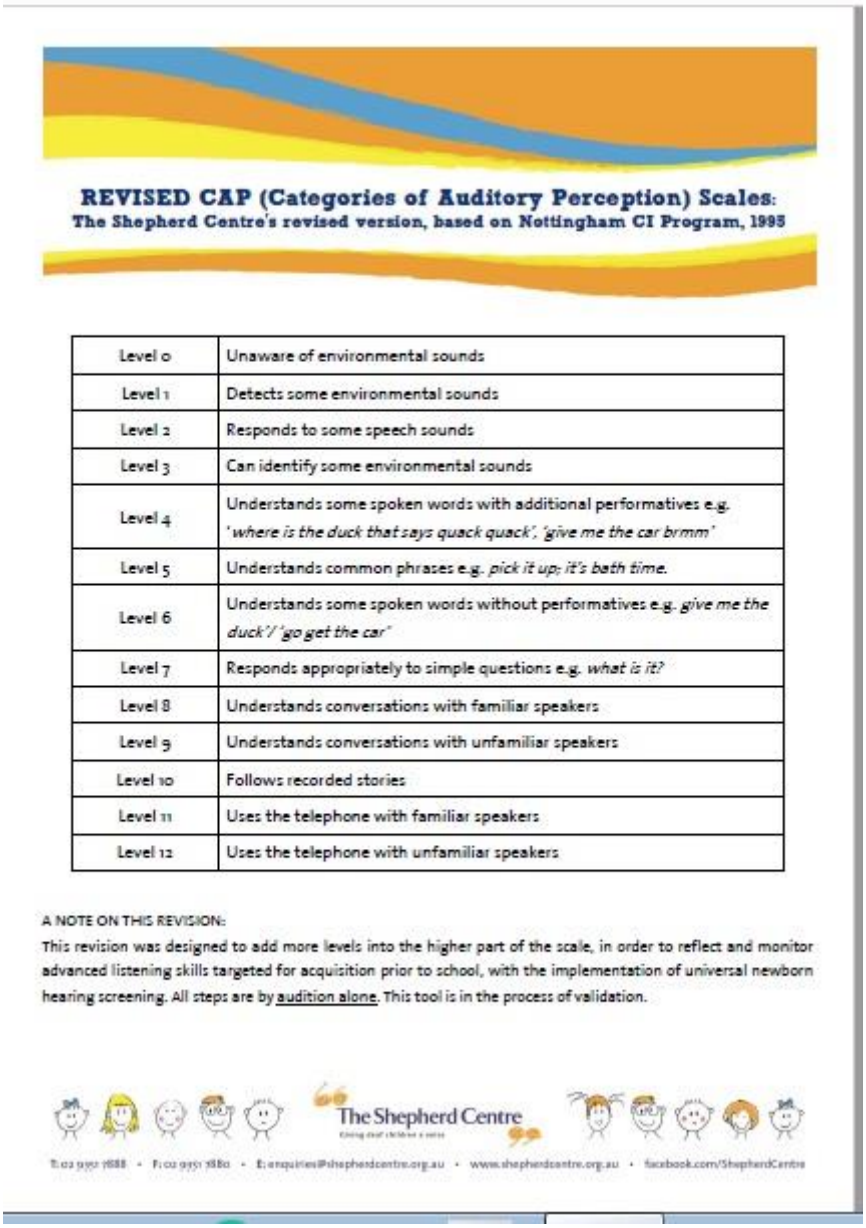
The children were trained on their respective listening age tasks and the time period (months) at which each activity was learned is recorded. The level of the acquisition was analyzed based on Categories of Auditory Performance (CAP) Scores at the end of 6 months of training. For finding efficiency, the level of the child was compared with the median score of CAP rating scale which consists of 12 levels. For sustainability, the results of 6 months of therapy and one-month post-therapy were studied. The resultant data were statistically analyzed to formulate the treatment manual.

STATISTICAL ANALYSIS

All the statistical analyses were carried out using STATA software version 14. Categorical variables such as age group and activities were summarized as numbers and percentages. The CAP scores at the end of 6 months training and one month post training was summarized as mean (SD) and median(IQR). The normality of the data was tested using Shapiro- Wilk's test. Since the data were non-normally distributed Wilcoxon Signed rank test was used to compare the CAP scores at the end of 6 months training and one month post training for all the four age groups studied. A p-value less than 0.05 was considered significant for all the analyses.

A NOTE ON CAP – Revised.

The revised CAP rating scale is an assessment tool developed by The Shepherd center based on Nottingham CI Program, 1995. It is a child-safe NDIS service provider specializing in helping children with H.L to learn to listen and speak. The revised version was designed to add more levels into the higher part of the scale, in order to reflect and monitor advanced listening skills targeted for acquisition prior to school, with the implementation of universal newborn hearing screening. There are 12 steps that rate the performance of the child based on hierarchical complexities of expression and language usage. All steps focus on audition alone.



REVISED CAP (Categories of Auditory Perception) Scales:
The Shepherd Centre's revised version, based on Nottingham CI Program, 1995

Level 0	Unaware of environmental sounds
Level 1	Detects some environmental sounds
Level 2	Responds to some speech sounds
Level 3	Can identify some environmental sounds
Level 4	Understands some spoken words with additional performatives e.g. *'where is the duck that says quack quack', 'give me the car brmm'*
Level 5	Understands common phrases e.g. *pick it up; it's bath time.*
Level 6	Understands some spoken words without performatives e.g. *give me the duck'/ 'go get the car'*
Level 7	Responds appropriately to simple questions e.g. *what is it?*
Level 8	Understands conversations with familiar speakers
Level 9	Understands conversations with unfamiliar speakers
Level 10	Follows recorded stories
Level 11	Uses the telephone with familiar speakers
Level 12	Uses the telephone with unfamiliar speakers

A NOTE ON THIS REVISION:
This revision was designed to add more levels into the higher part of the scale, in order to reflect and monitor advanced listening skills targeted for acquisition prior to school, with the implementation of universal newborn hearing screening. All steps are by audition alone. This tool is in the process of validation.

The Shepherd Centre

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A NOTE ON ANGEL SOUND

Angel Sound is a PC-based interactive listening rehabilitation program developed by Tiger Speech Technology and freely distributed by Emily Shannon Fu Foundation, a non-profit organization. It is an interactive auditory training and hearing assessment program that lets the therapist or individual take control of the listening rehabilitation independently. It has age-appropriate listening materials for hearing-impaired children who have cochlear implant devices or hearing aid devices to facilitate their language development.

ETHICAL CONSIDERATIONS

The treatment was given after taking consent from the parents. The objectives of the study, method, and duration of the treatment protocol were clearly informed. They were also assured that the habilitation planned is harmless with no financial benefit for the researcher and confidentiality will be maintained regarding children's details and study results.

CHAPTER 4
RESULTS

The current study mainly focuses on identifying stack development and validation of auditory habilitation protocol for children with cochlear implants. The study was carried out on four age groups viz 0-6 months of switch on, 6-12 months of switch on, 12-18 months of switch on and 18-24 months of switch on. They had to undergo training of 10 tasks, 12 tasks, 12 tasks, and 16 tasks respectively. Each taskwastrained children on different auditory hierarchical skills and had different number of activities based on their listening age and complexity of acquisition.These were grouped under different language developmental domains namely awareness, identification, vocalization, expression and comprehension of complex activities. It was analyzed that if any activity is completed by less than 30% of the children then that activity can be removed from the task assuming that the difficulty of achieving the task is so high for the children of this age.

The data was analyzed with Wilcoxon's Signed Rank Test. It was hypothesized that the CAP score at the end of 6 months therapy and one month post-therapy is at least the same. The findings were examined with the alternative hypothesis for acceptance& determining the improvement one month post-therapy in the CAP scores.

4.1 Training domains and effects of training given on implant age group of 0-6 months

The children were trained mainly on 4 domains viz. awareness, identification, vocalization and expression. In awareness stage, the participants had to perform particular activities in listening to the given auditory stimulus (conditioned play response). Six activities were provided and more than 30% of the children could perform all the activities.

In identification phase the participants were trained on six tasks namely environmental sounds, ling six sounds detection, name call response, same or different tasks, spontaneous alerting responses and suprasegmental's which had respectively five, six, one, seven, ten and nine activities. The vocalization phase trained participants on increased vowel vocalization and consonant-vowel vocalization which had four and six activities respectively. More than 30% of the participants could complete it.

The expression phase trained children on production of simple words. 16 out of 20 activities could be completed by more than 30% of the children.

Table 4.1 *Shows the tasks based on different auditory hierarchical domains under age group 0-6 months. The digits in the brackets indicate the no of activitieslearned/ trained.*

Sl. No	**Awareness**	**Identification**	**Vocalization**	**Expression**
1.	Conditioned play response(6/6)	Environmental sounds(5/5)	Increased vowel vocalization(4/4)	Production of simple words(16/20)
2.		Lings six sound detection(6/6)	Consonant-vowel vocalization(6/6)	
3.		Name call response(1/1)		
4.		Same or different task(7/7)		
5.		Spontaneous alerting responses(10/10)		
6.		Suprasegmental's(9/9)		

Comparison of baseline CAP scores vs CAP scores at the end of 6 months therapy.

Comparison of CAP scores at the end of 6 months training vs CAP scores one month post training.

The study examined the various results based on the activities under each task and found the percentage of children who completed the activities of task I to task X under 0-6 months age group. Shapiro-wilk test was done (pre-post difference) to test the normality of the data. A significant p value (P= 0.034) for Shapiro-Wilk test suggest that the data was non-normally distributed. Therefore, the appropriate test to assess the statistical difference is Wilcoxon signed-rank test.

Table 4.2: *Shows the CAP Scores at the end of 6 months training and one month post trainingof implant age group 0-6 months.*

Sl. No.	Name of Child	CAP Score at the end of 6 months therapy	CAP Score post one month therapy
1	A P	5	5
2	A J	5	5
3	R C S	4	4
4	AA	3	4
5	AL	6	6
6	M R	2	3
7	E C	6	7
8	A V	7	7
9	HZ	6	6
10	HD	6	6
11	LS	5	5
12	KI	4	5
13	SH	5	5
14	JP	4	4
15	R S	5	5

The median(IQR) CAP value at the end of six months therapy and one month post-therapy were 5(4-6) and 5(4-6) respectively. There was an increase in the mean value of 0.3. Wilcoxon signed rank test was applied and a p-value of 0.046 was obtained which showed an increase in the score and found to be statistically significant. A significant improvement was showed one month post-therapy in comparison with the end of six months therapy.

Table 4.3 *Comparison of CAP values at the end of six months training and one month post-training of implant age group 0-6 months.*

	N	Mean(SD)	Mean(IQR)	Z	P
End of Six-month training	15	4.8(1.3)	5(4-6)		
One month post training	15	5.1(1.1)	5(4-6)	-2.0	0.046

4.2 Training domains and effects of training given on implant age group of 6-12 months

The children were trained mainly on 3 domains viz. vocalization, expression and comprehension. The vocalization phase trained participants on consonant vowel vocalization with five activities. More than 30% of the participants could complete it.

The expression phase had eight different tasks which trained children on production of simple words of categories like animals, body parts, colors, food, family, numbers, actions and general. It had ten, five, five, ten, five, ten, ten and forty-five activities respectively. In family category, only 4 out of 5 activities could be learned by majority of the children whereas in general category only 40 out of 45 activities could be learned by more than 70% of the children. Activities of all the other 7 tasks could be learned by more than 70% of the implantees.

The comprehension phase trained children on three tasks namely two-word commands, familiar expressions and pure-tone discrimination which had ten, seven and three activities respectively. In pure-tone discrimination, only 2 out of 3 activities could be learned by majority of children whereas other two tasks could be completed by majority of the participants.

Table 4.4*Shows the tasks based on different auditory hierarchical domains under age group 6-12 months. The digits in the brackets indicate the no of activities learned/ trained.*

Sl. No	**Vocalization**	**Expression**	**Comprehension**
1.	Consonant-vowel vocalization(5/5)	Production of simple words-animals(10/10)	Two-word commands(10/10)
2.		Production of simple words-body parts(5/5)	Familiar expressions(7/7)
3.		Production of simple words-colors(5/5)	Pure-tone discrimination(2/3)
4.		Production of simple words-food(10/10)	
5.		Production of simple words-family(4/5)	
6.		Production of simple words-numbers(10/10)	
7.		Production of simple words-actions(10/10)	
8.		Production of simple words-general(40/45)	

The study examined the various results based on the activities under each task and found the percentage of children who completed the activities of task XI to task XII under 6-12 months age group. Hence the p value of Shapiro-wilk test, (pre-post difference) was significant at (P= 0.031), the data falls to be non- normally distributed and Wilcoxon signed rank test was used.

Table 4.5: *Shows the CAP Scores at the end of 6 months training and one month post training of implant age group 6-12 months.*

Sl. No	Name of Child	CAP Score at the end of 6 months therapy	CAP Score post one month therapy
1	F R	5	5
2	L R	4	4
3	YS	6	8
4	DD	7	8
5	SA	5	6
6	TH	5	5
7	LA	5	6
8	HA	5	6
9	SU	4	4
10	M R	6	7
11	RE	6	6
12	VI	6	6
13	PR	7	8
14	H P	7	8
15	P S	6	6

The median (IQR) CAP value at the end of six months therapy and one month post-therapy were 6(5-6)and 6(5-8) respectively. There was an increase in the mean value of 0.6. Wilcoxon signed rank test was applied and a p-value of 0.005 was obtained which showed an increase in the score and found to be statistically significant. A significant improvement was showed one month post-therapy in comparison with the end of six months therapy.

Table 4.6*Comparison of CAP values at the end of six months training and one month post-training of implant age group 6-12 months.*

	N	**Mean(SD)**	**Mean(IQR)**	**Z**	**P**
End of Six-month training	15	5.6(0.9)	6(5-6)		
One month post training	15	6.2(1.37)	6(5-8)	-2.8	0.005

4.3 Training domains and effects of training given on implant age group of 12-18 months

The children were trained on 2 domains viz. comprehension and expression.The comprehension phase trained children on three tasks namely single directions, two directions and classroom instructions which had twenty, ten and ten activities respectively. All the activities could be completed by majority of the participants.

The expression phase had nine different tasks which trained children on production of simple words of categories like animals, body parts, colors, food, family,two-digit numbers, actions, general and melodic variations. It had ten, five, five, ten, five, ten, ten, forty-five and five activities respectively.

In color category, only 4 out of 5 activities; food category 9 out of 10 activities; two-digit numbers category 4 out of 10 activities; general category 37 out of 45 and in melodic variation only 3 out of 5 activities could be learned by majority of the children. Activities of all the other 4 tasks could be learned by more than 70% of the implantees.

Table 4.7*Shows the tasks based on different auditory hierarchical domains under age group 12-18 months. The digits in the brackets indicate the no of activities learned/ trained.*

Sl. No	Comprehension	Expression
1.	Single Directions(20/20)	Production of words-animals(10/10)
2.	Two Directions (10/10)	Production of words-body parts(5/5)
3.	Classroom instructions(10/10)	Production of words-colors(4/5)
4.		Production of words-food(9/10)
5.		Production of words-family(5/5)
6.		Production of two-digitnumbers(10/10)
7.		Production of words-actions(10/10)
8.		Production of words-general(40/45)
9.		Melodic variations-Puretone(3/5)

The study examined the various results based on the activities under each task and found the percentage of children who completed the activities of task XXIII to task XXXIV under 12-18 months age group. Hence the p value of Shapiro-wilk test, (pre-post difference) was significant at (P= 0.999), the data falls to be non- normally distributed and Wilcoxon signed rank test was used.

Table 4.8: *Shows the CAP Scores at the end of 6 months training and one month post trainingof implant age group 12-18 months*

Sl. No	Name of Child	CAP Score at the end of 6 months therapy	CAP Score post one month therapy
1	A B	4	4
2	S C S	6	8
3	KE	7	8
4	D S	6	7
5	M S	6	8
6	TA	6	6
7	DH	7	9
8	PN	7	8
9	MG	6	7
10	TA	7	9
11	TN	6	7
12	V S	6	6
13	AK	7	7
14	SR	8	9
15	FA	7	7

The median (IQR) CAP value at the end of six months therapy and one month post-therapy were 6(6-7) and 7(7-8) respectively. There was an increase in the mean value of 0.9. Wilcoxon signed rank test was applied and a p-value of 0.002 was obtained which showed an increase in the score and found to be statistically significant. A significant improvement was showed one month post-therapy in comparison with the end of six months therapy.

Table 4.9:*Comparison of CAP values at the end of six months training and one month post-trainingof implant age group 12-18 months.*

	N	Mean(SD)	Mean(IQR)	Z	P
End of Six-month training	15	6.4(0.9)	6(6-7)		
One month post training	15	7.3(1.3)	7(7-8)	-3.8	0.002

4.4 Training domains and effects of training given on implant age group of 18-24 months

The children were trained on 2 domains viz. comprehension and expression. The comprehension phase trained children on five tasks namely three step directions, multi-element directions, familiar expressions, melodic variations and male/ female voice identification which had eight, ten, five, five and four activities respectively. In three step direction, only 4 out of 8 activities whereas in multi-element directions, only 1 out of 10 activities could be completed by more than 70% of children.The other three task's all activities could be completed by majority of the participants.

The expression phase had eleven different tasks. The children were trained on production of simple words of categories like animals, body parts, colors, food, family, three digit/ complex numbers, actions and general. It had ten, five, five, ten, five, ten, ten and forty-fiveactivities respectively.

In body parts category, 4 out of 5activities; color category, only 3 out of 5 activities; food category, 9 out of 10 activities; three digit/ complex numbers category, 0 out of 10 activities and in general category only 39 out of 45 activities could be learned by majority of the children.

Imitation/ production of a word-Onomatopoeia had 20 activities of which 17 could learned by majority whereas rhyme recitation(partly) and story narration(partly) could be achieved by more than 30% of the subjects.All activities of the tasks; production of words of animals and actions category could be learned by more than 70% of the implantees.

Table 4.10*Shows the tasks based on different auditory hierarchical domains under age group 18-24 months. The digits in the brackets indicate the no of activities learned/ trained.*

Sl. No	**Comprehension**	**Expression**
1.	Three step directions(4/8)	Imitation/Production of a word-Onomatopoeia(17/20)
2.	Multi-element directions (1/10)	Production of words-animals(10/10)
3.	Familiar expressions(5/5)	Production of words-body parts(4/5)
4.	Melodic variations(5/5)	Production of words-colors(3/5)
5.	Male/female voice identification(4/4)	Production of words-food(9/10)
6.		Production of words-family(5/5)
7.		Production of complex two/ three-digit numbers(0/10)
8.		Production of words-actions(10/10)
9.		Production of words-general(39/45)
10.		Rhyme recitation –partly(5/5)
11.		Story narration – partly(5/5)

The study examined the various results based on the activities under each task and found the percentage of children who completed the activities of task XXXV to task XXXXX under 18-24 months age group. Hence the p value of Shapiro-wilk test, (pre-post difference) was significant at (P= 1.345), the data falls to be non- normally distributed and Wilcoxon signed rank test was used.

Table 4.11: *Shows the CAP Scores at the end of 6 months training and one month post trainingof implant age group 18-24 months*

Sl. No	Name of Child	CAP Score at the end of 6 months therapy	CAP Score post one month therapy
1	AY	6	6
2	RD	7	7
3	JH	6	7
4	MR	9	11
5	AR	8	9
6	LY	6	6
7	AN	7	8
8	JL	8	10
9	MM	8	9
10	IM	9	11
11	YE	8	10
12	SH	6	6
13	SR	7	8
14	AA	6	6
15	AM	7	9

The median (IQR) CAP value at the end of six months therapy and one month post-therapy were 7(6-8) and 8(6-10) respectively. There was an increase in the mean value of 1.0. Wilcoxon signed rank test was applied and a p-value of 0.002 was obtained which showed an increase in the score and found to be statistically significant. A significant improvement was showed one month post-therapy in comparison with the end of six months therapy.

Table 4.12:*Comparison of CAP values at the end of six months training and one month post-trainingof implant age group 18-24 months.*

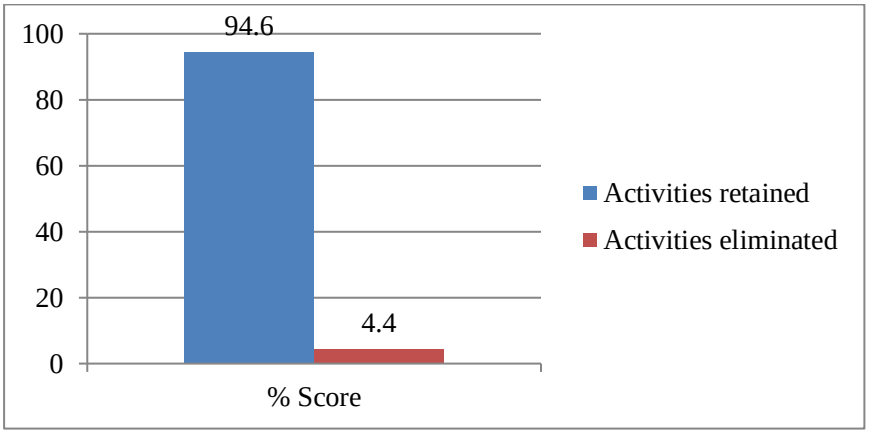
	N	Mean(SD)	Mean(IQR)	Z	P
End of Six-month training	15	7.2(1.08)	7(6-8)		
One month post training	15	8.2(1.82)	8(6-10)	-3.08	0.002

The number of activities performed under each taskand included in the manual is described in detail.

4.5 Compilation of activities learned/ retained and eliminated under implant age group 0-6 months

In 0-6 month's implant group, there were 10 tasks and 75 activities in total. 71 out of 75 activities could be achieved by more than 30% of the participants. This shows that nearly 95% of the activities could be acquired.

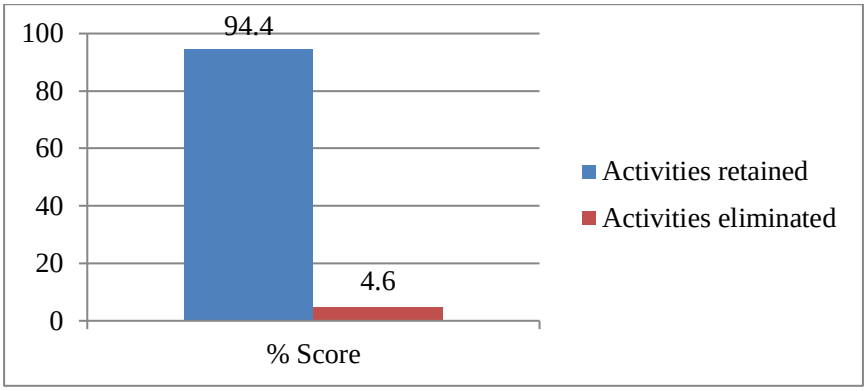
Figure 4.1: *Figure showing the % score of activities learned by the implant age group 0-6 months.*



4.6 Compilation of activities learned/ retained and eliminated under implant age group 6-12 months

In 6-12 month's implant group, there were 12 tasks and 125 activities in total. 118 out of 125 activities could be achieved by more than 30% of the participants. This shows that nearly 94.4% of the activities could be acquired.

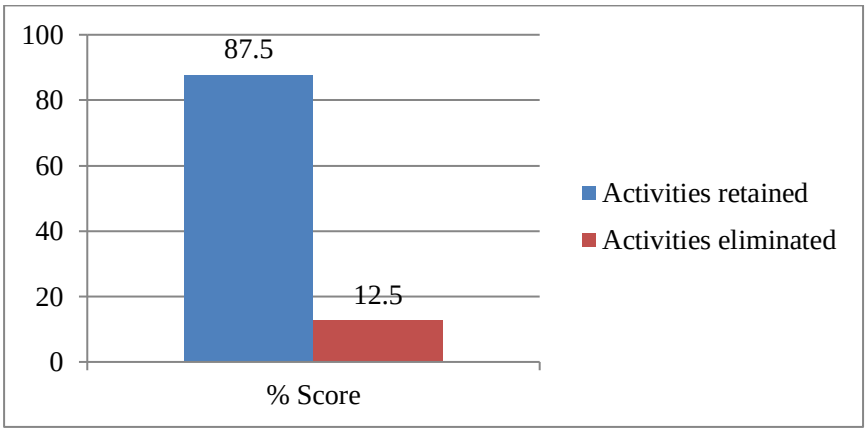
Figure 4.2: *Figure showing the % score of activities learned by the implant age group 6-12 months.*



4.7 Compilation of activities learned/ retained and eliminated under implant age group 12-18 months

In 12-18 month's implant group, there were 12 tasks and 145 activities in total. 127 out of 145 activities could be achieved by more than 30% of the participants. This shows that nearly 87.5% of the activities could be acquired.

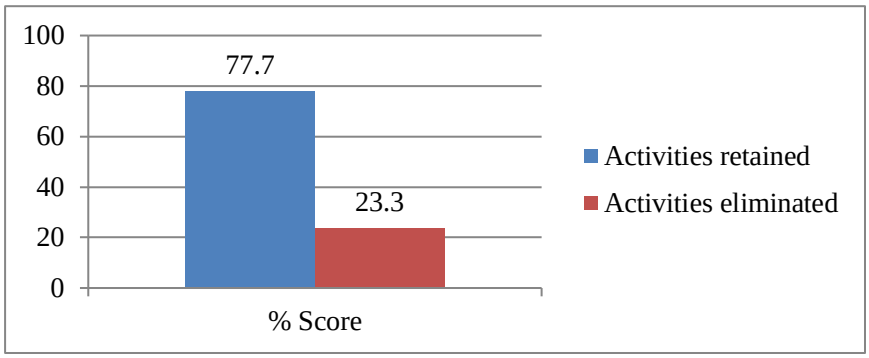
Figure 4.3: *Figure showing the % score of activities learned by the implant age group 12-18 months.*



4.8 Compilation of activities learned/ retained and eliminated under implant age group 18-24 months

In 18-24 month's implant group, there were 16 tasks and 162 activities in total. 126 out of 162 activities could be achieved by more than 30% of the participants. This shows that nearly 77.7% of the activities could be acquired.

Figure 4.4: *Figure showing the % score of activities learned by the implant age group 18-24 months.*



4.9 Formulation of auditory habilitation protocol/ AV treatment manual.

The study consisted of a total of 50 levels of tasks with each level having multiple learning activities. The total number of activities numbers to about 507. A statistical criterion of significant increase in the success of acquiring listening or auditory comprehension skills was considered as benchmark for the activity to be included in the manual. The embedded criterion was also that 30% of the subjects should learn the activity in each task. Based on this criterion, from the 50 tasks, approximately 442 activities will be included in the manual. Thus 87.2% of the activities were finally selected for the auditory habilitation training material.

Figure 4.5: *Figure showing total no of activities trained, no of activities achieved/ selected and no of activities eliminated from all age groups.*

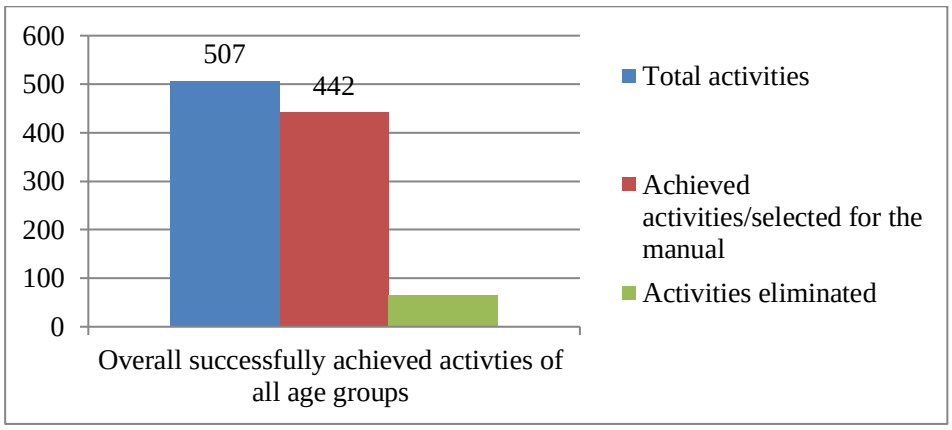
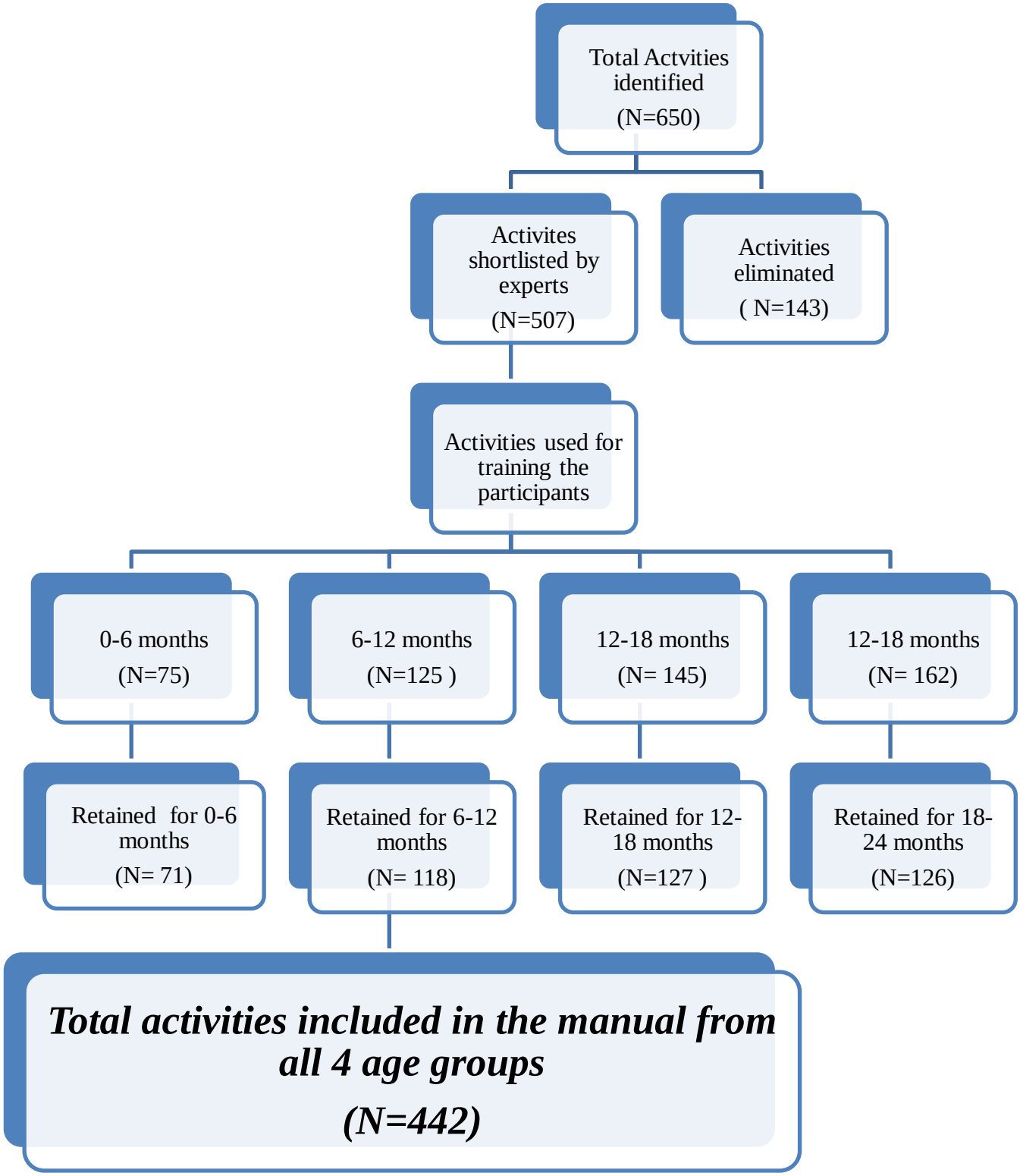


Figure 4.6: *Matrix showing the development stages of activities for the manual.*



CHAPTER5

DISCUSSION

5.1 Implant age 0-6 months

The children (N=15) were trained on awareness, identification, vocalization and expression aspects. All the awareness activities could be performed by more than 30% subjects of the study. In identification phase also, more than 30% participants could learn to identify the common environmental sounds, ling sounds, response to name call, difference between same or different task, spontaneous alerting and suprasegmental's. In general, awareness and identification activities were developed within 6 months of implant use.

Vocalization aspect trained children on vocalization of various consonants in relation to all the vowels. Majority of the participants could learn to produce the activities within 6 months of training. In expression phase, children were trained on production of simple words. Around 16/20 words could be learned by majority of the participants. This shows that simple words can be achieved within six months of AV training itself.

5.2 Implant age 6-12 months

The participants (N=15) were trained on vocalization, expression and comprehension activities. Majority of the participants could achieve vowel vocalization with respect to all consonants by 6-12 months of implant age.

The expression of simple words of different categories – animals, body parts, colors, food items, family, numbers, actions and in general were well appreciated by majority of children. Except one activity in family task and 5 activities in general task, all the other activities could be learned by majority of the pediatric implantees.

Two words commands and familiar expressions were successfully acquired by majority of the children in their 6-12 months of implant age. In comprehension phase (pure-tone discrimination task), majority of the participants could identify difference between high and mid frequency sounds where as low frequency sounds could not be learned by majority of the children.

5.3 Implant age 12-18 months

The subjects of the study group (N=15) were trained on comprehension and expression aspects. Comprehension tasks trained on single directions, two directions and classroom instructions. All the activities could be learned by majority of the subjects which shows that the activities are well suited for the age group.

Expression phase trained subjects on expression of various words belonging to categories such as animals, body parts, colors, food items, family, numbers, actions, and general category. Except one activity among colors, food items and five in general words category; majority of the children learned to produce the other activities in the training period. On melodic variations training; rising, falling and flat patterns could be learned by majority of participants whereas combination of two tones could be learned by only less than 30% of the children.

5.4 Implant age 18-24 months

The participants of the study group (N=15) were trained on comprehension and expression tasks. Comprehension aspects focuses on three step directions and multi-element directions where only 4 out of 8 and 1 out of 10 activities could be learned by majority of the children. All the activities under familiar expressions, melodic variations and male/female voice identification could be achieved majority of the children.

In expression phase, complex activities were trained on. In imitation/production of a word/ Onomatopoeia, 17 out of 20 activities could be learned by majority of the children. Production of complex words belonging to category – animals& actions, rhyme recitation (partly) & story narration (partly) could be achieved by majority of the participants. Activities such as production of complex words belonging to categories – body parts, colors, food, family and general categories; 4 out of 5, 3 out of 5, 9 out of 10 and 39/45 only could be completed by majority of the children. The complex two digit and three-digit numbers could not be learned by any of the children.

In general, 87.2% of the activities were learned by more than 30% of the children.

CONCLUSIONS AND IMPLICATIONS

The manual is basically an AV module that can be used on personal computer. The present study considered that systematically training CI recipients' keeping a track of the baseline achievements is very important in measuring the success of AR. Further details will be presented in the expanded version.

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